ELECTRICAL AND COMPUTER ENGINEERING
PhD QUALIFYING EXAMINATION

Session 1

January 8, 2007

Be sure to put your ID number on each sheet that has material to be graded. Do not put your name on any sheet.

There are 14 equally weighted problems. You are to SELECT ANY EIGHT of these to answer. You must make it very clear which eight that you choose. (If it is not clear, then the first eight problems that you attempt will be graded.) Indicate your selections in two ways:

1. Circle below which eight problems that you want graded.
2. If you write anything other than your ID number on the page of a question that you do not graded, the cross out that page with a large X from corner to corner.

Circle the eight questions that you want graded:

1

2

3

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14

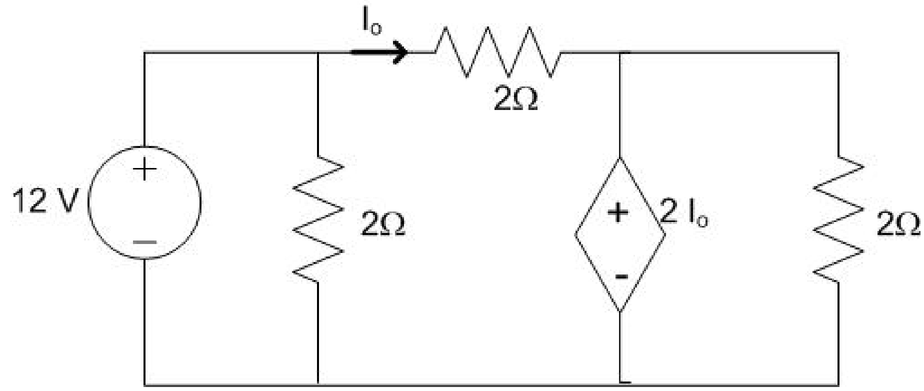
Do all work on the paper supplied to you. Do not write on the back of any page.

Problem 1-1 ID # ________________________

Using D flip-flops, design a synchronous counter, which counts in the sequence of (1, 3, 5, 0, 2, 4, 6, and then repeats). The counter only counts when its enable input x is equal to '1' otherwise the counter is idle.

Problem 2-1 ID # ______________________

Find the value of I_o in this circuit.



Problem 3-1 ID # ________________________

1. Given that $x[n] = \sum_{m=-\infty}^{\infty} \delta[n-3m]$ and that $h[n] = u[n] - u[n-7]$ and that $y[n] = x[n] * h[n] = \sum_{m=-\infty}^{\infty} h[m]x[n-m]$, find the numerical value of $y[4]$.

$$\left[\delta[n] = \begin{cases} 1 \ , & n = 0 \\ 0 \ , & n \neq 0 \end{cases} \quad , \quad u[n] = \begin{cases} 1 \ , & n \geq 0 \\ 0 \ , & n < 0 \end{cases} \right]$$

Problem 4-1 ID # ________________________

Find the area of the region that lies inside the circle $r = 3\sin\theta$ and outside the cardioid $r = 1 + \sin\theta$.

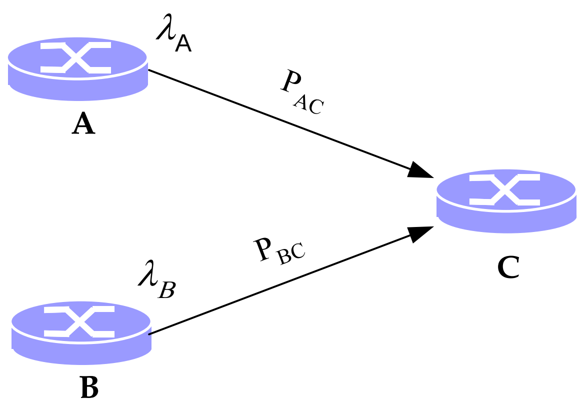
Problem 5-1 ID # ___________________________

Write a recursive C++ function to reverse in place the elements of an array A, where the array has n>0 elements.

Problem 6-1 ID # ________________________

Consider the network shown in figure 1, in which all packets are of fixed size and time is slotted into packet-size intervals. The probability of Router A generating a packet during each time slot is λ_A, and the probability that Router B generates a packet during each time slot is λ_B. Packets transmitted from Router A to Router C have a probability of error p_{AC}, while packets transmitted from Router B to Router C have a probability of error p_{BC}. Packet generations and error events are assumed to be mutually independent.

a. What is the average number of packets that arrive at Router C per time slot?
b. Calculate the probability that during a single time slot at least one packet arrives successfully at Router C?
c. Calculate the probability that during N time slots no packets arrive at Router C? (Note: packets that arrive with errors are dropped).



Problem 7-1 ID # _________________________

Part A) Find the Average Memory Access Time (AMAT) for a processor with a 2 ns clock, a miss penalty of 20 clock cycles, a miss rate of 0.05 misses per instruction, and a cache access time (including hit detection) of 1 clock cycle. Assume that the read and write miss penalties are the same and ignore other write stalls.

Part B) Suppose we can improve the miss rate to 0.03 misses per reference by doubling the cache size. This causes the cache access time to increase to 1.2 clock cycles. Using the AMAT as a metric, determine if this is a good trade-off.

Problem 8-1 ID # ___________________________

Suppose that arrays A and B are both sorted and each contains N elements. Give an O(logN) algorithm to find the median of (A union B).

Problem 9-1 ID # ______________________

Here is a table of processes and their associated arrival and running times:

Process ID	Arrival Time	Expected CPU Running Time
Process 1	0	5
Process 2	3	5
Process 3	5	3
Process 4	7	2

Show the scheduling order for these processes under First-In-First-Out (FIFO), Shortest-Job First (SJF), and Round-Robin (RR) with a quantum = 1 time unit. Assume that the context switch overhead is 0 and new processes are added to the head of the queue except for FIFO.

Time	FIFO	SJF	RR
0	1	1	1
1	1	1	1
2	1	1	1
3	1	1	2
4			
5			
6			
7			
8			
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For each process in each schedule above, indicate the queue wait time and turnaround time (TRT). The queue wait time is the *total* time a thread spends in the wait queue. The turnaround time is defined as the time a process takes to complete after it arrives.

Scheduler	Process 1	Process 2	Process 3	Process 4
FIFO queue wait				
FIFO TRT				
SJF queue wait				
SJF TRT				
RR queue wait				
RR TRT				

Problem 10-1 ID # ____________________________

Solve the system of linear equations:

$$\begin{aligned} -x_2 - x_3 + x_4 &= 0 \\ x_1 + x_2 + x_3 + x_4 &= 6 \\ 2x_1 + 4x_2 + x_3 - 2x_4 &= -1 \\ 3x_1 + x_2 - 2x_3 + 2x_4 &= 3 \end{aligned}$$

(a) Represent the system of linear equations in a matrix equation of the form $\boldsymbol{Ax} = \boldsymbol{b}$ where $\boldsymbol{x} = \begin{bmatrix} x_1 & x_2 & x_3 & x_4 \end{bmatrix}^T$.

(b) Find a row echelon form of the augmented matrix $[\boldsymbol{A} \mid \boldsymbol{b}]$.

(c) Is the system of equations consistent? Justify your answer.

(d) Solve the equation.

Problem 11-1 ID # ________________________

Relating to the *pn* Junction Diode:

a. What carrier gradient is needed to generate a diffusion current density of $J_n = 1000\ A/cm^2$ if $\mu_n = 500\ cm^2/V\cdot s$?

b. Suppose a drift current density of 1000 A/cm^2 exists in the neutral region of the n-type side of a diode that has a resistivity of 0.5 $\Omega\cdot$cm. What is the electric field needed to support this drift current density?

Problem 12-1 ID # ________________________

A small factory has several different types of loads which are grouped together as follows:

Induction motors: 500 kW, 0.85 lagging average power factor
Heating loads: 50 kW at unity power factor

A three-phase, synchronous motor is installed at the factory to provide 300 kW to a new process pump and to improve the factory's overall power factor. With the synchronous motor providing 300 kW to the new process pump, calculate how much reactive power the synchronous motor must supply to the system to maintain an overall factory power factor of 0.95 lagging. What is the kVA and power factor of the synchronous motor for this operating condition?

Problem 13-1 ID # ________________________

A generator with a 100 Ω source impedance and a 10V peak voltage, is connected to a transmission line of a 1.5 wavelength and 100Ω characteristic impedance, the line is connected to an antenna with equivalent input impedance of (80-j40) Ω,

a) What is the input impedance at the source side?
b) What is the VSWR along the line?
c) What the input current? What is the load current? How much power delivered to the load?
d) Use a single stub match loading to have a perfect match at the center frequency?
e) If the operating frequency is increased by 10%, what the new input impedance and reflection coefficient?

Problem 14-1 ID # ________________________

You have an 8 MHz FM exciter, one or more frequency doublers and a heterodyne unit (multiplier, oscillator and bandpass filter). The FM exciter has a message bandwidth of 3 kHz, and a frequency deviation of 6 kHz. Using these components, design a system that will output your message at a carrier frequency of 90 MHz and will have a frequency deviation of 24 kHz. Clearly label all blocks, their signal inputs/outputs, etc. of your system and justify that your design is correct.

Problem _-_ ID # ___________________________